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From: General Aviation Human Factors Program Manager, AAR-100
To: General Aviation TCRG

Subj: GENERAL AVIATION HUMAN FACTORS THIRD QUARTER ’03 REPORT

Ref: (a) General aviation human factors execution plans

1) Per reference (a), the third quarter 2003 report for each general aviation human factors projects are listed below.

   a) Human Error and General Aviation Accidents: A Comprehensive, Fine-Grained Analysis using HFACS

      As part of the collaborative agreement with the University of Illinois, CAMI was instructed to conduct a more fine-grained HFACS analysis of the individual human causal factors associated with general aviation accidents and to assist in the generation of possible intervention programs. While the HFACS analysis provided unique insight into the types of errors (skill-based, decision, perceptual) and violations committed by GA aircrew, a larger question remained regarding exactly what type of errors committed within each error category? In other words, how often do skill-based errors involve stick-and-rudder errors, verses attention failures (slips) or memory failures (lapses)? Equally important, within a given error type (e.g., skill-based errors), how often is each category of error the “primary” or seminal cause of an accident? For example, 80% of accidents might be associated with skill-based errors, but how often are skill-based errors the “initiating” error versus simply the “consequence” of another type of error, such as decision errors?

      As part of that effort, the University of Illinois (Capt. Troy Faaborg, USAF and Dr. Douglas Wiegmann) recently completed an examination of the seminal unsafe acts associated with 2,716 fatal GA accidents occurring between 1990-98. This work was part of a larger effort being conducted at CAMI on all GA accidents occurring between 1990-2000 (over 18,000 human error related accidents).

In brief (the larger report will be presented at the GA Program Review in Reno), regardless of whether the accident data is plotted as a percentage of accidents associated with at least one occurrence of a given aircrew causal factor or as the a relative percentage of those accidents where a given aircrew casual factor was the first "seminal" aircrew error in the chain of events, the data looks essentially the same. In fact, CAMI has recently updated Dr. Wiegmann and Capt. Faaborg's May report with fatal data from 1990-2000 (see figures below).

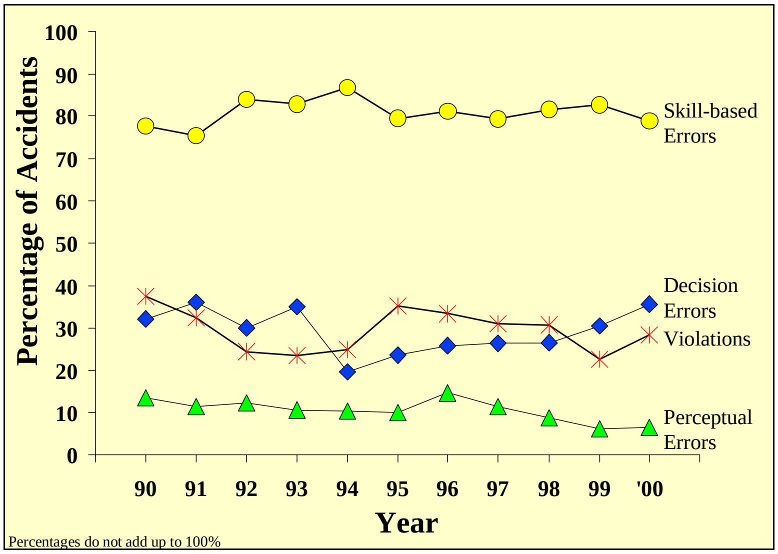

Figure 1. Percentage of accidents associated with at least one type of unsafe act.

The preceding figure depicts the percentage of accidents associated with at least one aircrew error (skill-based, decision, or perceptual error) or violation associated with it. What this figure illustrates is that when all fatal GA accidents associated with aircrew error are examined, roughly 80% are associated with skill-based errors, roughly 30 % associated with decision errors, etc. Note that the percentages do not add up to 100% because accidents can be associated with multiple causal factors.

While this proved interesting, the question remained whether the relationship would change if one only considered those errors or violations that initiated the events that led to an accident. When the data are examined in this way, no trivial effort I might add, the pattern remains the same (see figure below). That is, skill-based errors continue to be the leading error form precipitating accidents, followed by decision errors, violations and perceptual errors. Note that these accidents due add up to 100%.

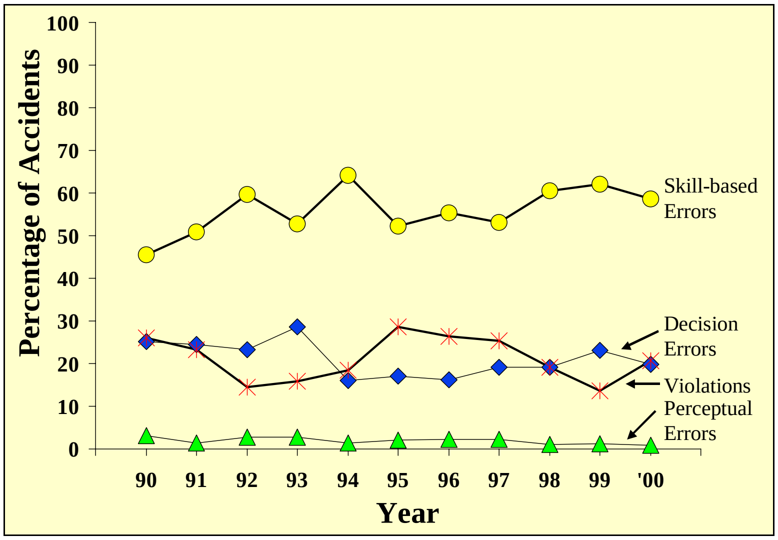

Figure 2. Percentage of accidents where a particular causal category was the first "seminal" aircrew error in the accident chain.

With the delivery of the CY2000 update in the third quarter, CAMI and the University of Illinois are actively pursuing all milestones identified in the execution plan and are on, or ahead of schedule, in every case.

In addition to the documented milestones, CAMI and the University of Illinois are actively pursuing several other lines of research in response to inquiries as a result of a briefing at HQ by Dr. Shappell in June. Included are the following:

- An examination of the pattern of human error associated with Alaska GA accidents compared with the rest of the U.S.
- An examination of the pattern of human error associated with different phases of flight.
- A comparison of the pattern of human error associated with fixed-wing versus rotary wing accidents.
- An examination of the human causal factors associated with the recent increase in fatal GA accidents.

Although these additional investigations are not part of the original execution plan, no additional funding is required to address them.

Awards/Recognition

In recognition of their work in the development and implementation of HFACS within the military and civilian aviation organizations around the world, Dr. Scott Shappell and Dr. Douglas Wiegmann were presented the *Harry G. Moseley*

Award (2003) by the Aerospace Medical Association for significant contributions to human factors and aviation safety.

Publications/ Presentations FY03, Third Quarter

Wiegmann, D. and Shappell, S. *A human error approach to aviation accident analysis: The human factors analysis and classification system.* Ashgate Publishing Limited. Aldershot, UK

Shappell, S.A. & Wiegmann, D.A. (2003). *A human error analysis of general aviation controlled flight into terrain accidents occurring between 1990-1998*. (Technical Report DOT/FAA/AM-03/4). Washington, DC. Office of Aerospace Medicine.

Presented opening address at International Seminar on Human Factors and Health in Aviation, Bogata, Columbia (June, 2003).

HFACS presented to the Columbia Space Shuttle Accident Investigation Board (May, 2003). Houston, TX.

Shappell. S.A. & Wiegmann, D. A. (2003). Reshaping the way we look at general aviation accidents using the Human Factors Analysis and Classification System. *Proceedings of the 12th International Symposium on Aviation Psychology*. Dayton, OH.

Faaborg, T., Wiegmann, D., & Shappell, S. A. (2003). Decision errors and general aviation accidents: A fine-grained analysis using HFACS. *Aviation, Space, and Environmental Medicine, 74*(4), 460.

Shappell, S. A., & Wiegmann, D. (2003). Human error associated with general aviation controlled flight into terrain. *Aviation, Space, and Environmental Medicine, 74*(4), 460.

Shappell. S.A. & Wiegmann, D. A. (2003). A comparison of U.S. military and civilian aviation accidents using the human factors analysis and classification system (HFACS). In J. Beaubien and R.K. Dismukes (Chairs). *Error Reporting, Classification and Analysis as Part of a Comprehensive Risk Management Strategy*. Panel presented at the 12th International Symposium on Aviation Psychology. Dayton, OH.

All indications indicate that this project is on track to complete the milestones as planned.

b) Comparison of the Effectiveness of a Personal Computer Aviation Training Device, a Flight Training Device and an Airplane in Conducting Instrument Proficiency Checks.

Between April 1 and June 30 four pilots started the study. During this reporting period 33 pilots have been scheduled for all types of sessions. A total of five pilots completed IPC#1 and seven pilots completed IPC#2, thereby completing the study. The following table shows the totals for Q3 as of June 30,2003:

Quarter Session Runs

Air-fam*	PCATD-fam*	Frasca-fam*	IPC#1	IPC#2	P-Training	F-Training	A-Training	All types:	# of Subjects Started
63	65	64	54	51	27	44	1	369	75

In terms of the total number of subjects who have started the study, of 75 started, 66 are continuing or have completed the study. Of these 75 subjects started, 51 have completed the study. There are 52 subjects yet to be scheduled. As of June 30, a total of 369 sessions have been scheduled. A total of 54 pilots have completed IPC#1 and 51 pilots have completed IPC#2, thereby completing the study.

All indications indicate that this project is on track and will be completed in FY04.

c) Credit for Instrument Rating in a Flight Training Device or Personal Computer

i. Phase I: Survey UAA, Part 61, and Part 141 institutions. Report submitted to AAR-100 on December 31st, 2002.

Project completed.

ii. Phase II: Capabilities of FTDs/PCATDs. The study completed data collection and plans to submit the final report in the next couple of months. Preliminary results to the TCRG questions are as follows:

1. *How are FTDs and PCATDs being used by general aviation training organizations to train pilots seeking certification as a private or commercial pilot, or to add instrument or multi-engine class ratings to their certificate?*

   The data show most organizations use FTDs and PCATDs for instrument instruction. The data also reveal that some organizations are using devices to teach some tasks that are outside the realm of instrument training. A few schools are even attempting to teach some visual maneuvers in these devices. Flight training devices are the predominate devices used, although in some tasks schools appear to be attempting to use made more use of PCATDS. Other training aids show little use in most all tasks.

2. *Which FTDs are in use, including make, model, date of manufacture, and certification level?*

   The data collected revealed the type of device, manufacturer, make and level of certification by the responding flight schools. In some cases, the data was incomplete as to the level of certification. The FTDs reported were primarily from three manufacturers and the certification levels ranged from not certified to level 6 devices.

3. *Which PCATD devices are being used, including software and hardware packages?*

   The data collected also revealed the type of PCATDs being used. In most all cases, the devices were from four primary manufacturers.

4. *Which tasks are being taught in each type of device?*

   The collected data does reveal which tasks are being taught in each type of device. The data is depicted in graphs that show the number of students being taught each task in each device. Most of the tasks that are taught are instrument or procedural related with a few efforts being made to teach visual flight maneuvers. Most of the tasks are taught in FTDs.

5. *How are devices being used to enhance training and skill proficiency?*

   While the devices are being used in various training course outlines to teach a wide range of tasks, it is not clear how they are being used enhance skills and proficiency. An analysis of the data does not show that the use of these devices actually reduces the flight time required to achieve certification. This suggests that the devices may be used to fulfill time requirements or perform remediation training and not necessarily to reduce flight time.

6. *Are devices being used appropriately according to NSP guidelines and criteria?*

   The data suggest that not all devices are being used in accordance with NSP guidelines and criteria. The exact nature of how the devices are not being used in accordance with the guidelines and criteria is not clear, but the data suggests a lack of knowledge of the certification requirements for these devices.

7. *Are all devices (FTDs) appropriately certified?*

   The data suggest that not all devices may be appropriate certified, or at the least, the persons responding to the survey were unsure of the certification of their devices.

8. *How much are the devices being used to augment training in an "unofficial" manner (for example, unlogged time spent to familiarize students with IFR tasks)?*

   The data suggest that both students and instructors use training devices outside the curriculum for familiarization and remediation purposes. The effect of this type of use on the overall flight time at the end of the course is not clear.

Indications are that this activity is on track. The draft report was submitted to AFS-800 representatives for comment. The final report will be delivered before September 30th, 2003.

iii. Phase III: Transfer of Training Effectiveness of a Flight Training Device (FTD). A total of 65 students have completed the AVI 130 Basic Instrument course and have taken the stage check for the course. Table 1 shows the results of the stage check. A total of 41 students passed the check ride on the first attempt and 23 students passed on the second attempt. One student failed the check ride on the second attempt and was recommended for a remedial course, AVI 102. Five other students failed to complete the course and were recommended for AVI 102.

Table 1. Flight Lesson 45 Statistics (Fall, 2002 and Spring, 2003)*

	Airplane Only	PCATD 5.00	Frasca 5.00	Frasca 10.00	Frasca 15.00	Frasca 20.00
Number of Students	13	11	9	11	11	10
% First Flight Pass Rate	46.15 (N=6)	72.73 (N=8)	66.67 (N=6)	72.73 (N=8)	81.82 (N=9	40.00 (N=4)
% Second Flight Pass Rate	100.00 (N=7)	100.00 (N=3)	100.00 (N=3)	100.00 (N=3)	50.00 (N=1)	100.00 (N=6)
Students Recommended 102	0	0	1	1	2	2
Total Dual to Completion	22.89 (N=13)	19.40 (N=11)	18.79 (N=9)	19.16 (N=11)	18.74 (N=10)	17.06 (N=10)
Variance Total Dual to Completion	10.68	7.65	5.74	8.71	5.66	11.53

This lesson is the stage check for AVI 130.

A total of 32 students have completed the AVI 140 course, Advanced Instruments, and have taken the final check ride for the course (the instrument rating flight check). Table 2 shows the results of the check ride. A total of 18 students passed the check ride on the first attempt and 14 students passed on the second attempt. The 6 students in AVI 140 for the spring semester who were recommended for AVI 102, a remedial course, fail to complete the course during the spring semester and therefore were not given an instrument rating flight check.

Table 2. Lesson 60 Statistics (Spring 2003)*

	Airplane Only	PCATD 5.00	Frasca 5.00	Frasca 10.00	Frasca 15.00	Frasca 20.00
Number of Students	6	6	4	5	5	6
% First Flight Pass Rate	83.33 (N=5)	50.00 (N=3)	100.00 (N=4)	20.00 (N=1)	40.00 (N=2)	50.00 (N=3)
% Second Flight Pass Rate	100.00 (N=1)	100.00 (N=3)	(N=0)	100.00 (N=4)	100.00 (N=3)	100.00 (N=3)
Students Recommended 102	1	0	2	1	2	0
Total Dual to Completion	27.42 (N=6)	26.87 (N=6)	25.55 (N=4)	23.28 (N=5)	20.70 (N=5)	20.68 (N=5)
Variance Total Dual to Completion	11.26	5.70	7.10	3.52	4.39	11.45

Flight Lesson 60 is the Instrument Rating check ride for AVI 140

Indications are that this activity is on track.

d) <u>Developing And Validating Criteria for Constraining False & Nuisance Alerts For Cockpit Display Of Traffic Information Avionics</u>. Sixteen subjects out of 24 have completed Experiment 1 and some preliminary results can be reported.

Experiment 1's objective is to develop a cognitive model of the features of unaided conflict prediction, that is, pilot prediction made without the aid of intelligent automation. This model will reveal the pilot vulnerabilities that are in greatest need of automation support and suggest design solutions to provide such support. For example, prior data has suggested that predicting the spatial/temporal implications of speed changes is more difficult than predicting the implications of heading and altitude change. The experiment will also suggest, by implication, the pilot vulnerabilities to unreliable predictions. This latter goal is based on the assumption that more difficult cognitive predictions will induce greater reliance upon automated assistance, and have as a result more serious consequences when the predictor is incorrect and the pilot must suddenly rely upon the raw data to estimate future trajectories.

Methods: <u>Independent variables</u>: (1) Distance to closest point of approach (DCPA; between-subjects, short, medium, and long) (2) Angle of Convergence (AOC; within-subjects, 45º, 90º, and 135º), (3) intruder's relative speed to ownship (RS; within-subjects, 2:1, 1.5:1, 1:1, .75:1, and .5:1), and miss distance, lateral (MDL; within-subjects, randomly sampled from + 5 nm — + 8 nm, +3 nm — + 5 nm, 0 nm — + 3 nm, 0 nm — - 3 nm, -3 nm — -5 nm, and -5 nm — - 8 nm). <u>Dependent variables:</u> (1) Estimation accuracy of DCPA, relative bearing at closest point of approach (RBCPA), and time to CPA (TCPA). Procedure: The CDTI to be used for this experiment was a modified version of the coplanar display developed by Merwin and Wickens (1996; Wickens et al., 2000). It depicted ownship and traffic in a map (top-down) view.

Preliminary Results: The results of the preliminary analysis, based on the first 16 subjects' data, are encouraging. They either substantiate some of the hypotheses or show the tendency in the hypothesized direction. The following is a summary of the results with respect to the TCPA and DCPA prediction accuracies as they are the two major dependent variables for this experiment; RBCPA prediction results are pending data reduction and coding at this time.

TCPA prediction accuracy

- Increasing DCPA, TCPA, and MDL, and reducing relative speed, made the TCPA prediction more difficult (i.e., reduced absolute TCPA estimate accuracy).
- There seemed to be no difference in terms of TCPA prediction accuracy whether the intruder was passing in front of or behind the ownship, as defined by RB-CPA 180˚ apart (i.e., 0˚ vs. 180˚, 45˚ vs. 225˚, and 135˚ vs. 315˚). It is noteworthy that when the intruder aircraft was on a relative track with an RBCPA of 0˚ or 180˚, the TCPA estimate was the most accurate as compared to other values of RBCPA. That is, when the intruder traffic was approaching on a relative track parallel to the two horizontal sides of the computer screen, the TCPA prediction was most accurate.
- Whether the intruder was approaching from right to left or from left to right also did not make a difference for the TCPA estimate accuracy. The right-left approaching intruder was associated with AOC's of 45˚, 90˚, and 135˚, and the left-right approaching intruder had AOC's of 225˚, 270˚, and 315˚. The horizontal relative tracks also corresponded to two AOC's: 90˚ and 270˚. In other words, these two AOC's were associated with the most accurate TCP prediction.
- The data of the signed TCPA estimate accuracy reveal the following results. For a same true TCPA, the TCPA estimate was longer with a longer DCPA and faster relative speed than with a shorter DCPA and slower relative speed. And for a same DCPA, the TCPA estimate was relatively longer with faster relative speed and shorter TCP than with slower relative speed and longer TCPA. Therefore, the distance-over-speed hypothesis was supported.

DCPA prediction accuracy

- Increasing DCPA, TCPA, and the true MDL made the prediction of the DCPA more difficult (i.e., reduced absolute DCPA estimate accuracy). However, relative speed of 240 knots was associated with the poorest DCPA prediction, compared to 160 knots and 480 knots.
- As with the TCPA prediction, whether the intruder was passing in front of or behind the ownship made no difference for the DCPA prediction accuracy. Again, the DCPA prediction was the most accurate when the RBCPA was 0˚ or 180˚.
- As in the case of the TCP prediction, which side the intruder was flying from (right-left or left-right) had no effect on the DCP prediction accuracy. Again, prediction was most accurate for the horizontal relative tracks with an AOC of 90˚ or 270˚.

Most of the work on the project during the third quarter focused on the development of experimental design and protocols to develop a cognitive model of the features of unaided conflict prediction, that is, pilot prediction made without the aid of intelligent automation. This model will reveal the pilot vulnerabilities that are in greatest need of automation support and suggest design solutions to provide such support. The specific goals of the experiments are (1) to examine how different geometric variables will influence unaided conflict detection with the CDTI using estimate accuracy of distance to closest point of approach (DCPA), relative bearing at the closest point of approach (RBCPA), and time to the closest point of approach (TCPA), (2) to identify the features that make unaided conflict detection difficult or easy, (3) to identify biases that affect performance (e.g., distance-over-speed bias) in Experiment 1.

Experiment 2 will further examine (4) how correct automation can improve performance via conflict predictor and (5) how different types automation imperfections (e.g., due to heading or speed change of the intruder) will influence performance. The independent variables are: (1) Task difficulty (between-subjects, easy and difficult as determined from the results of Experiment 1), (2) automation reliability (within-subjects, correct in 48 trials, incorrect in 12 trials), (3) automation error due to heading change and speed change, and (4) six levels of automation errors (2 FA's, 1 bad FA, 2 misses, 1 bad miss, see table below)

	Predictor Indication		
Miss Dist.	***No Alert***	***Low Alert***	***High Alert***
> 5 nm	Correct Rejection	False Alarm	Bad False Alarm
3-5 nm	Miss	Hit	False Alarm
<3 nm	Bad Miss	Miss	Hit

Dependent variables will be identical to Experiment 1 and the subjects will be recruited from the same pool as in Experiment 1.

Indications are that there are minor risks to the activity being completed as planned. A no-cost extension will be authorized until the end of the year (December 31, 2003) with respect to Experiment 2 results; the researchers will deliver an interim report with complete results from the literature reviews and Experiment 1 on the original project completion date of August 23, 2003.

e) <u>Low Visibility and Visual Detection</u>

The grant was awarded on April 1st, 2003. So far, the researcher has purchased a PCATD, digital camera and accessories to begin data collection of images in the aviation environment. The researcher has begun construction of the PCATD apparatus and testing room facility at the University. Data collection has begun for images in the aviation environment as proposed in Phase 1 of the project. Approximately 150 images have been so far collected in the Reno area, the Los Angeles basin, Arizona, New Mexico, Texas, and Florida. Recruitment procedures have begun for a postdoctoral student and a graduate student.

Indications are that this activity is on track.

William K. Krebs